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SUPPLEMENTARY REPORT ON INVESTIGATIONS OF FISH-SALVAGE PROBLEMS IN RELATION TO SHASTA DAM

By

Paul R. Needham, Harry A. Hanson, and Lewis P. Parker

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Explanatory Note

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Supplementary Report on Investigations of Fish-Salvage Problems in Relation to Shasta Dam

By

Paul R. Needham, Harry A. Hanson, and Lewis P. Parker

FOREWORD

The following report presents the results of biological investigations in the Sacramento Valley and the status of the Shasta Salmon Salvage Project since Special Scientific Report No. 10 (Hanson, Needham, and Smith, 1940) was published in April 1940.

Investigations of the fisheries problems and construction of the salvage facilities are financed by the U. S. Department of the Interior, Bureau of Reclamation, and are under the supervision of the Fish and Wildlife Service.

The history of the project and the salvage plan are presented in section I; the status of salvage facilities is presented in section II; the data gathered during the investigations on the Sacramento River are presented in section III; and those on Deer Creek are presented in section IV. A list of the major topics included in this report is given in the table of contents.

SUMMARY

1. Shasta Dam became an impassable barrier to upstream migrating salmon on November 8, 1942.

2. No salmon will be transferred above the dam in 1943 because of the dangers to the young in passing the dam on their way to the sea.

3. Only two streams entering the Sacramento River between Shasta Dam and the mouth of Feather River have any salvage possibilities. These are Battle Creek and Deer Creek.

4. The salvage plan recommended by the Board of Consultants and accepted by the U. S. Bureau of Reclamation was placed in operation in the spring of 1943.

5. Counts of salmon passing Redding have been made for six years and the run is estimated to be about 60,000 fish per year.

6. From observations on the natural spawning of the 1942 fall run salmon in the Sacramento River, it is apparent that they spawned successfully in the main river below Keswick Dam.

7. Installation of the middle rack in November 1942 was unsuccessful both because of early high water and the fact that it could not be made fish-tight during the short time it was maintained.

8. The number of native-run salmon in Deer Creek, estimated from partial counts, was 635 in 1941, 1,108 in 1942, and 812 in 1943.

9. In June 1941, 920 salmon were transferred experimentally to Deer Creek from the Sacramento River. Of these, 309 were marked by clipping off the adipose fin and 179 by clipping off a portion of the dorsal fin.

10. During the spawning of the 1941 spring-run salmon in Deer Creek, 1,463 fish were recovered and examined to determine how completely they had spawned. Among these were thirteen that had been marked by clipping off the adipose fin. This recovery of marked fish would indicate that salmon can be transferred successfully to Deer Creek from the Sacramento River.

11. A utilization study of the gravel spawning areas in Deer Creek was made at the conclusion of the spawning of the 1941 spring run salmon. A total of 2,704 nests were counted from the lower falls to the Deer Creek Irrigation Company Dam in lower Deer Creek.

12. The estimated number of native and transferred salmon in Deer Creek in 1941 was 7,000. This number was obtained by allowing 1 female and 1.65 males to each of the 2,704 nests. The ratio of 1:1.65 was the proportion found between the sexes of dead salmon examined during the spawning season.

13. It was recommended that 10,000 instead of 6,000 spring-run fish be transferred to Deer Creek in the spring of 1943 but because of various difficulties, only 5,245 were transferred. Of this number, 24.4 per cent were lost before spawning began.

14. Delay in completion of trapping facilities in Keswick Dam resulted in heavy losses to the 1943 spring run.

15. Fyke netting for seaward-migrant chinook salmon was carried on in Deer Creek from November 1941 to July 1942, and from February 10 until June 7, 1943. The first migrant was taken in early December 1941. In 1942, a peak migration of 109 fry was observed from March 9 to 15. The peak catch in 1943 was made between March 1 and 6.

16. Stream temperature records of Deer Creek show a range at the weir site of from 43°F. to 86°F., and between Campbellville and the lower falls, a range of from 43°F. to 70°F.

PERSONNEL AND ACKNOWLEDGMENTS

General supervision of the salmon salvage problem was under Dr. Paul R. Needham, Aquatic Biologist, Dr. James W. Moffett, Associate Aquatic Biologist, and Dr. Osgood R. Smith, Assistant Aquatic Biologist, of the Fish and Wildlife Service. Harry A. Hanson, Associate Aquatic Biologist, directed the program in the field. He was assisted by Lewis P. Parker, Assistant Aquatic Biologist, and Leo F. Erkkila, Assistant Aquatic Biologist. Additional temporary assistants were employed from time to time to assist in the investigation. Among these were Verl L. House, Thomas J. Beland, Norman W. Mattoon, and J. Frank Massey, Senior Laborer-Fish Counters, and Ralph H. Olson and Frank I. Barmettlor, Senior Biological Aides. The fish counting at the Redding Dam in 1940 and 1941 was done by William O. Williams and Robert A. Morley. Harlan B. Holmes, In Charge, North Pacific Fishery Investigations, has directed the work in connection with design of the fish ladders and traps and other engineering problems. The fish cultural aspects of the problem were under the supervision of Alphonse Kemmerich, Regional Supervisor of Fish Culture, and his staff, and John Pelnar, District Supervisor of the Coleman Station. They also cooperated with the Division of Fishery Biology on all phases of the problem. Thad M. Blake, Superintendent of the Coleman Station, gave much aid in the experimental transfer of salmon to Deer Creek.

The authors are indebted also to many other persons who cannot be named here for their generous help and advice during the course of the investigation.

INTRODUCTION

Shasta Dam, on the upper Sacramento River in northern California, is nearing completion, and it has already become an impassable barrier to important runs of chinook salmon that formerly spawned in the Little Sacramento, McCloud, and Pit Rivers.

A plan for a large dam on the Sacramento River has been in print since 1933 (Bulletin 26, California State Water Plan, Sacramento River for 1931), but bids were not sent out to the contractors until April 1938. The bids were opened on June 1, 1938, and construction began in September of the same year. Shasta Dam is to be a multiple purpose dam for navigation improvement, flood control, supplemental irrigation, salinity control in the lower Sacramento Delta region, and electrical power generation.

Keswick Dam is under construction about nine miles below Shasta Dam. This dam will create an afterbay reservoir both for power and for smoothing fluctuations in river discharges from the Shasta power plant. It will also serve as a barrier to upstream migrating fish, and fish ladders and elevators will be constructed in it for trapping and transfer of salmon to other waters.

From 1938 to 1942, construction of Shasta Dam was confined mainly to the east and west abutment sections on each side of the river, permitting the river to flow unimpeded through the spillway section between them. It was not until November 8, 1942, that construction in the spillway section reached a stage where it formed an impassable barrier to upstream migrating fish. It had previously been expected that the dam would become impassable in late 1941 or early 1942, but because of war conditions, construction is behind schedule. Although the dam is now a barrier to upstream migrations, early 1943 seaward migrants may pass safely over the center blocks during high water periods in the winter, and later they will pass through the diversion tunnel. The Southern Pacific Railroad tunnel, abandoned when the railroad was relocated, is to be used for diverting the river when the water behind the dam reaches the level of the old railroad bed. During periods of high river discharges, water may be discharged over the lower blocks of the spillway section giving the seaward migrants an additional means of passing the dam.

Effect of Operation of Dam on Fish

Shasta Dam forms an impassable barrier to migrating fish because of its height and the nature of its operation. Although it might be possible and practical to transfer adult salmon over the dam on their spawning migrations, nothing is known as to how they would react when confronted with the slack waters of the reservoir. If the adult salmon migrated up through the reservoir and spawned successfully in the streams above, there still would remain the problem of getting the young safely

down past the dam on their way to the sea. These young fish would be subjected to sudden pressure changes, hazardous routes through the penstocks and turbines, and finally the tremendous turbulence that will occasionally occur at the base of the dam. It would not be practical to screen these passageways or attempt to divert the salmon through a special chute or by-pass, because of the great volume of water and the fluctuation in forebay levels amounting to 237 feet. Once past Shasta Dam, if the passage could be accomplished safely, the young salmon would almost immediately encounter similar dangers at Keswick Dam. The mortality that would result from such a hazardous trip makes it apparent that it would be useless to transfer mature salmon above the dam.

Present Water Utilization

The removal of water from streams for irrigation is a serious hazard to both upstream and seaward migrating fish. In some cases there is practically no water at the mouth of the tributary stream to attract upstream migrants nor sufficient water to permit safe passage for downstream migrants.

Numerous irrigation diversions leave only eight permanently flowing streams entering the Sacramento River between Shasta Dam and the mouth of Feather River. Of these eight streams, only two, Battle Creek and Deer Creek, have possibilities for the salvage of salmon. Battle Creek is the only stream with appreciable flow during the summer months. This flow is the result of an extensive canal system which carries spring water to the Coleman Powerhouse about four miles upstream from the mouth. Above the powerhouse most of the water is removed by ditches, and the little that does remain is too warm for salmon.

Deer Creek has a suitable flow except during the irrigating season when it is almost dry for the lower several miles. It can, nevertheless, be used for natural propagation in the upper reaches where stream conditions are suitable for salmon.

Outline of Salmon Biology

The runs of salmon in the Sacramento River are made up almost entirely of one species, the chinook salmon (Oncorhynchus tschawytscha). The life history of the chinook salmon does not differ markedly from those of the other four species of Pacific salmon. Most of the feeding and growth of salmon occur in the ocean where they spend from two to seven years. When they near maturity, they enter fresh water to spawn, and all die after spawning. The eggs are buried in the gravel of clear, cold streams where they incubate for from one to three months, depending on the water temperature.

After the fry have hatched they remain in the gravel until the yolk sac is almost absorbed. When the time comes for feeding to begin, the young fry emerge from the gravel and start their seaward migration. The time required to get to the ocean depends on conditions in the streams and on the distance the fry must travel. In the Sacramento system most fry reach the ocean in the spring soon after hatching.

Salmon have a well developed homing instinct, or tendency, which directs most of them to return and spawn in the same river in which they started life, and marking experiments have indicated that they will also return to a stream in which they were reared after transplanting. There undoubtedly is some straying from the "parental streams," but the homing tendency is pronounced enough to form the basis of most salmon management regulations.

The Salvage Plan

In Special Scientific Report Number 10 (Hanson, Needham, and Smith, 1940), four plans were presented for salvaging the runs of Sacramento River salmon blocked by Shasta Dam. The Bureau of Reclamation appointed a Board of Consultants consisting of R. D. Calkins, now Dean of the College of Commerce at Columbia University, W. F. Durand, Professor (Emeritus) of Mechanical Engineering at Stanford University, and Willis H. Rich, Professor of Biology at Stanford University, to review the four plans and to recommend the most feasible from both the economic and biological points of view. The plan recommended by the Board of Consultants and accepted by the U. S. Bureau of Reclamation is known as the Sacramento River, Battle Creek, Deer Creek Plan. A few minor revisions were necessitated by additional information gathered during field investigations and experimental work from 1940 through 1942, but essentially the plan has remained as the Board recommended it on June 21, 1940. It is as follows:

Plan for Salvage of Salmon in Relation to Shasta Dam[1/]

Time	Est. No. of fish	Operation of the plan
Jan. 1 to June 15	12,000	Transfer of 10,000 spring-run salmon to Deer Creek for natural propagation. Transfer of 2,000 spring-run salmon to Battle Creek to be held until ripe for artificial propagation.
June 16 to Oct. 10	18,000	Transfer of 18,000 summer and early fall-run salmon to Battle Creek for artificial propagation. Installation of the Sacramento River racks to be completed by October 1 preparatory to putting the fall spawning plan into operation as soon as river temperatures become suitable.
Oct. 1 to Dec. 31	30,000	Put fall spawning plan into operation by closing off river racks and distribute 30,000 fall-run salmon in the river for natural propagation by counting the adult salmon into each natural spawning area.

1/ This table was based on the assumption that fish trapping facilities were to be ready for operation around May 1, 1943.

The salvage facilities required to carry out this plan are as follows:

Salvage Facilities

1. Fish ladder, traps, and lifts in the Keswick Afterbay Dam and the Balls Ferry rack for trapping and removing salmon from the Sacramento River: The Keswick facilities will be used when river discharges exceed 15,000 c.f.s. and the Balls Ferry trap when river discharges are less.

2. Seven 1,000-gallon tank trucks to transfer salmon from Keswick and Balls Ferry to Battle Creek and Deer Creek.

3. Construction of a hatchery and facilities on Battle Creek as follows:

   a. A hatchery having a capacity of about 58,000,000 eggs or advanced fry, approximately 29,000,000 fingerlings averaging 1 1/2 inches, and such numbers of larger fingerlings as the facilities may provide.

   b. Twenty-eight outdoor ponds, 20 feet x 150 feet, for use as rearing ponds for advanced fry and fingerlings and holding ponds for some of the transferred adult salmon.

   c. A cold storage and ice-manufacturing building.

   d. Combined garage, shop, and warehouse.

   e. Dwellings for the operating personnel.

4. Five racks in main Battle Creek to form four holding and ripening pools for adult spring salmon transferred from the Sacramento River.

5. Three Sacramento River racks: This phase of the plan calls for a rack near the Balls Ferry bridge above the mouth of Battle Creek (See Map A), the Balls Ferry rack; another, or middle rack, about two miles above the county road bridge to Anderson; and a third, or upper rack, near the free bridge at Redding. The Balls Ferry rack is to be a multiple-purpose rack. It will be used (1) as a trap, (2) as an aid in the distribution of salmon in the river for natural spawning, and (3) as a barrier for a portion of the salmon to insure utilization of the riffles below Balls Ferry for spawning.

6. Hoists and overhead cableways for the installation and removal of the racks in the Sacramento River.

7. One rack with hoist and overhead cableway on Deer Creek: The Deer Creek rack is for counting natural-run salmon and to prevent transferred fish from returning to the Sacramento River.

8. A fish ladder around the lower falls in Deer Creek to make an additional five miles of that stream accessible to salmon for spawning.

Tentative plan of operation of the Coleman Station on Battle Creek

Time	Operation of the plan
January 1 to June 1	Care of the eggs and fry. Planting of majority of fry. Approximately 10 percent to be retained and subsequently released as fingerlings. Install racks in Battle Creek in late April or early May. Installation of Balls Ferry rack to begin when flows in Sacramento River drop below 15,000 c.f.s.
June 1 to October 10	Receive 20,000 spring-, summer-, and early fall-run salmon and hold them between the racks in Battle Creek and in the rearing ponds for ripening and later spawning. Installation of middle and upper racks in Sacramento River about October 1. Feeding of young salmon that are held over the summer.
October 1 to December 31	Spawn-taking operations will begin about October 1 and should be completed by the end of November. The main river racks and the Battle Creek racks will be removed as soon as spawning is completed. Care of eggs and care and feeding of young fish. First planting of fry about the end of December.

STATUS OF SALVAGE FACILITIES

Keswick Dam

Keswick Dam now forms the upstream limit of migrating fish. Consequantly, salmon that would normally migrate above Keswick Dam for spawning must either be held below the dam or removed at the dam and transferred elsewhere for spawning. The facilities for trapping and removing salmon are located in the center of the dam between the powerhouse and the spillway sections and will be used when river discharges exceed 15,000 c.f.s. The trapping facilities consist of a twelve-pool fishway or ladder, a sweep bay, a brail-lift, and a 1,000-gallon fish-tank elevator.

Construction of Keswick Dam started on October 4, 1941. The plan of construction provided for two stages. The first included the foundations and the base of the abutments, spillway, and powerhouse, and the nearly complete fish trap.

From October 1941 to May 1942, construction was confined mainly to the spillway section. On May 23, 1942, the coffer dam around the powerhouse section was completed, and the river was diverted through the spillway channel. A fish ladder was constructed to compensate for the 21-foot drop from the spillway channel to the bed of the river. However, shortly after the river was diverted, the downstream end of the ladder was undermined and it is doubtful if any fish were able to enter it.

In August 1942, the contract was extended to include completion of the dam and all facilities. However, late in 1942 the War Production Board ordered construction stopped on several dams including Keswick Dam. In the case of the latter, however, construction was to be continued until the fish trap and ladder were made operable. Despite various delays, this was accomplished on June 1, 1943, during the peak of the spring run.

Tank Trucks for Salmon Transfers

Seven tank trucks of 1,000-gallon capacity, similar to those used on the Columbia Basin Project, were built for transferring salmon from the Sacramento River to Battle Creek and Deer Creek. Four of these trucks were delivered on March 25, 1942, and the remaining three about thirty days later. However, on June 23, 1942, the U. S. Bureau of Reclamation was informed by its administrative officers in Washington, D. C., that the chassis of the trucks would have to be surrendered to war agencies. The Office of Defense Transportation suggested that second-hand trucks be obtained and the tanks removed and installed on them as soon as possible, in the meantime permitting the use of some of the new trucks until second-hand equipment could be purchased and made ready for use. In May 1943, however, the Office of Defense Transportation released all seven trucks and on June 1, 1943, they were put into service.

Coleman Hatchery and Facilities

The Coleman Station consists of a hatchery building, 232 feet by 88 feet; 28 outdoor rearing ponds, 20 feet by 150 feet by 3 feet, with provision for water control; a cold storage plant; a garage and warehouse; and six residences. In addition to these facilities, there will be five racks in Battle Creek to form four salmon-holding and -ripening pools and four fish-releasing platforms.

Construction of the cold storage plant and the six residences began on March 17, 1942. Two of the residences were completed on August 20, and the remaining four were finished a month later. The cold storage plant was completed on November 14, 1942, and installation of refrigeration equipment was finished early in 1943.

Excavation for the hatchery building started in mid-April 1942, but inclement weather slowed up operations for the first month. Construction started in June 1942, and the hatchery building was completed on November 14, 1942.

Construction of the outdoor rearing ponds, including the water supply canal from Battle Creek at the tailrace of the Coleman Powerhouse, and a drainage canal from the ponds to Battle Creek, that is fitted with a fish ladder and trap, has been completed. Excavation for the rearing ponds, water supply canal, and drainage system began on March 19, 1942, and these facilities were ready to handle spring-run salmon in the early summer of 1943.

The garage and warehouse is a one-story building, approximately 89 feet by 136 feet in size. It provides space for all fish-hauling and other trucks, and a large warehouse for tools and hatchery equipment. In addition, there are paint, blacksmith, welding, and machine shops, and facilities for washing, greasing, and repairing the trucks.

Construction of the garage and warehouse began in June 1942, and it was ready for use in March 1943.

The holding and ripening pools in Battle Creek are formed by five demountable racks across the stream. These racks will be installed each year about the first of May and dismantled at the conclusion of spawn-taking operations in late October. The tripods, stringers, walkways, and picket sections for all five racks were constructed during the summer of 1942. A wood, rock-filled crib foundation for rack No. 1 was completed in September 1942.

Construction of four ramps for releasing fish from the tank trucks was finished in time for fish transfers in the spring of 1943.

The Balls Ferry Rack and Trap

Bids were received on August 15, 1941, for the construction of the Balls Ferry rack and fish trap across the Sacramento River near the Balls Ferry bridge. As stated above, this rack is the farthest downstream of three racks to be installed in the Sacramento River below Keswick Dam and it has facilities for trapping and removing salmon from the river.

The rack consists of 30 round timber-pile bents driven at 16-foot intervals across the river. These bents will support the picket sections. Twelve feet upstream from the bents is a row of nine-inch Wakefield piling projecting approximately one foot above the river bottom, forming a continuous narrow sill across the stream. The picket sections are made of 3/4-inch standard pipe welded to steel cross bars with 1-1/2-inch clearance between pipes. Each section is 16 feet wide and 12 feet deep. The lower end of the picket section rests on the Wakefield piling and the upper end is hinged to the pile-bent platform. The structure is 593 feet long. The rack itself is 496 feet long with an additional 66 feet on the east end for the trap and truck bridge and 31 feet on the west end for the abutment section. A hoist, headtower, tailtower, and overhead cableway system have been constructed for installation and removal of the demountable rack sections.

The facilities for trapping and removing salmon consist of a sweep bay section, a brail-lift section, and a 1,000-gallon fish-tank elevator to raise the fish to the tank trucks. A 45,000 g.p.m. pump will be used to maintain a suitable flow of water through the trap to attract the fish. The Balls Ferry trapping facilities are operated in the same manner as those in Keswick Dam.

Construction of the rack and trapping facilities began in September 1941, but was discontinued three months later on December 3 because of high water. In May 1942, construction was resumed and all of the 30 round, timber-pile bents were driven by the end of the year. The Wakefield cut-off piling were driven at the same time. River discharges of 73,000 c.f.s. in late January 1943 washed out four bents and damaged several more. This was a relatively small flood for the Sacramento River, where 100,000 c.f.s. might be considered "normal" high water. However, the Balls Ferry rack was repaired and made operable by late spring, 1943.

The Middle and Upper Sacramento River Racks

As previously stated, these racks are to provide a more uniform distribution of salmon on the spawning beds between Balls Ferry and Keswick Dam. They will be installed each year about the first of October and dismantled after spawning nears completion in late November. Installation, maintenance, and removal of the racks will be done by main overhead and barge cableways.

Excavations for the anchors of the main cableway system for the middle rack were started on August 24, 1942. These were completed in September and excavations for the barge cableway system began. On October 13, 1942, a temporary barge line and endless cable were installed and placing of the rack tripods began immediately. The main cableway system was completed on November 19, and the rack was removed at that time because of high water.

All materials for the upper rack were purchased and ready for installation in the summer of 1943. However, it was jointly decided not to install this rack in 1943 for reasons discussed in the section titled, "Upper Rack" on page 33.

The Deer Creek Rack and Facilities

The Deer Creek rack was built with a rock-filled timber crib foundation, 100 feet by 14 feet, across the bottom of the stream, approximately 600 feet downstream from the county bridge across Deer Creek. This platform-covered crib remains in the stream at all times. Steel tripods, which support the stringers and picket sections, are set at 12-foot intervals on the permanent foundation. The picket sections are built-up panels two feet wide and six feet long with one by three-inch pickets fastened at intervals, leaving 1 1/4-inch openings between the pickets. A gasoline-operated hoist, a heavy timber headtower, a timber "A" frame tailtower, and an overhead cableway have been installed to remove and replace the rack sections and tripods.

In addition to the rack and cableway system at Deer Creek, there has been provided a three-room combination field office and dormitory. A temporary ramp from which the transferred fish could be released into Deer Creek was built and used in the spring of 1943. It will be replaced by a permanent structure in the near future.

Deer Creek Fish Ladder at the Lower Falls

Construction of a fishway or ladder around the lower falls on Deer Creek was begun in October 1942. A heavy snowfall on November 16 prevented any further work being done on the fishway until Spring of 1943. It was completed in late June 1943. This structure will allow the natural or transferred salmon to reach the upper portions of deer Creek not hitherto accessible to them.

BIOLOGICAL INVESTIGATIONS

Salmon Counts in the Sacramento River

For the past six years, 1937 to 1942, partial counts of salmon runs have been made as the fish passed through the ladder at the Anderson-Cottonwood-Irrigation-District Dam at Redding. The California Division of Fish and Game did the counting in 1937; the U. S. Bureau of Reclamation employed counters for counting from 1938 to 1941; and the U. S. Fish and Wildlife Service assumed the task in 1942.

The Redding Dam, where the counts were made, is a demountable structure operated only during the irrigating season. The dam is usually installed in April, when the need for irrigation water arises, and is maintained until late October or early November. During the installation and dismantling of the dam, fish leap over the flash boards; complete annual counts cannot therefore be obtained.

In 1937, salmon were counted as they passed through the ladder from August 7 to October 14. From October 16 to 23, an estimate was made of the salmon as they leaped over the partially dismantled dam. The actual count through the ladder was 5,280, and the estimate of fish going over the dam was 10,900.

On September 2, 1938, a weir was installed in the fishway and 13,885 salmon were counted to November 2, when the dam was lowered. It was estimated that about 5,500 more swam upstream after the dam was dismantled.

In 1939 a more complete count was attempted, and as a result, 21,894 salmon were counted through the weir from April 23 to December 8. The counting weir used in 1939 consisted of a metal screen with 1.5 -inch mesh. The fish passed through an opening near the top of the screen. To facilitate counting, a white board was placed at the base of the opening so that the fish could be readily observed in murky water. This same weir was used in subsequent years.

In 1940 counting started on May 16 and continued until dismantling of the dam began, October 25. From October 25 to October 31, the salmon were counted as they passed over the dam while the flash boards were being removed. The 1940 count of 40,248 was nearly double that of the previous year, although made over a two months' shorter period.

Counting was begun on May 17 in 1941 and continued until October 31; the total was 44,856. High water prevented the installation of the dam until the middle of May, so the 1941 count was also made over a two months' shorter period than in 1939. All counts clearly show a definite spring and fall peak with some fish running at all times. Appendix table 1 shows that the 1940 and 1941 counts were discontinued at, or possibly before, the peak of the fall run, and therefore the actual number of salmon passing Redding must be considerably higher than the count. Sample counts at Battle Creek and Mill Creek in 1940 and 1941 after the Redding count was discontinued indicate that salmon move up the Sacramento system in large numbers during November and December. This was observed at the Redding Dam during the 1939 counts, when the dam was not removed until December 8.

The 1942 count of 7,312 represents perhaps only a very small part of the run because excessively high water in the spring and the lack of sufficient personnel during the summer prevented continuous counting. Installation of the Redding Dam began about April 1, but high water from then until mid-June permitted the salmon to leap over the flash boards. From May 14 until June 14 counts were made of salmon passing over the first three, out of 68, bays of the dam. Although salmon passed over the dam to some extent until early July, the ladder was used for counting after June 14. On August 10, the fish counter entered the armed services and counting was discontinued until September 7 when another counter was employed who remained until October 15. On that date employees of the Irrigation District began to remove stop logs from the dam and further counting was impractical.

If the unknown part of the 1940 and 1941 runs is estimated from a proportion between the 1939 and 1940 runs, the total for the 1940 and 1941 seasons would be near 60,000 salmon by early December. We have no way of knowing that such a proportion would actually exist, because secondary peaks, or a difference in duration of the main peak, would upset the proportions. In fact, the 1940 and 1941 runs might actually have been much greater than 60,000. One thing is obvious, and that is the runs could not have been less than 50,000 in either year because the actual counts for a part of the season were 40,248 and 44,856, respectively, and each count was stopped at or before the peak of the fall run, allowing a good number of fish to go past Redding uncounted. As pointed out in Special Scientific Report No. 10, there is also a winter run of salmon, but nothing is known about its size.

Comparing the counts of 1940 and 1941 with those of 1939 and 1942, it becomes apparent that the salvage plan must be adjusted to great fluctuations in numbers of salmon and that no count to date has established the maximum numbers of salmon that may have to be handled.

Observations on Natural Spawning in the Sacramento River

Several inspection trips were made to observe the fall spawning of chinook salmon in the Sacramento River from November 3 to December 30, 1942. Observations were made both by boat and by foot.

The entire river was covered from Keswick Dam to Red Bluff. Salmon were found on all riffles where the gravel was suitable and visibility permitted observations of spawning. It was observed that the nests on many riffles were separated by unused gravel areas apparently as suitable as those where the nests were built. However, some of the riffles that were sparsely populated in early November were heavily populated with spawning salmon in early December. This was especially true at the mouth of Stillwater Creek.

The first two riffles below the Redding Dam were heavily utilized during the entire spawning season. This dam was a partial barrier from October 16 to November 8 when water was not flowing through the fish ladder and the flash boards were too high to permit the salmon to leap over them easily. Crowding of the salmon below the Redding Dam and lack of crowding farther downstream indicate that salmon did not drop far downstream below the barrier to spawn.

At the time the Redding Dam was a partial barrier, no salmon were observed to be spawning between it and Keswick Dam. After the flash boards had been removed and the water lowered, spawning activity was observed offshore on the shoal just below the new railroad bridge and on the riffle at the mouth of Middle Creek. Numerous fish spawned in the upper end of the diversion ditch close to the dam. On November 30, forty nests and sixty live salmon were counted there.

From November 5 to December 24, 499 dead salmon were recovered in the river from Keswick Dam to Red Bluff. These were cut open and their reproductive organs examined to determine how completely they had spawned. Of the 499 fish examined, 264 were males and 235 were females. A major proportion of these fish were completely spawned out. Almost 35 per cent of the partially spawned salmon had been snagged by fishermen. The observations indicated that "snaggers" cause some loss of spawning fish and for this reason the Fish and Wildlife Service recommended closure of the upper Sacramento River during the fall-spawning period.

It seems apparent from these observations that the 1942 fall run salmon spawned successfully in the Sacramento River below Keswick Dam. However, as previously stated, it is believed the 1942 run was smaller than the runs in 1940 and 1941, and the 1942 observations may not be typical of what to expect if larger runs are allowed to spawn under similar conditions.

Upper Rack

Early in 1943, it was decided not to install the upper rack this year. This decision was based on observations of natural spawning in the fall of 1942 and because the site selected left much to be desired.

Observations at the Middle Rack in Fall of 1942

Nothing was learned about the effect on the fish because the rack could not be made fish-tight. Very uneven ledges of bed rock on the bottom left large holes under the pickets which could not be stopped with stones because the current carried them on through. The water was too murky to see the holes, but they could be felt with a rake.

On November 14, it rained, raising the river slightly and bringing down great quantities of debris against the rack. Most of the debris was scrap lumber from construction work at Shasta and Keswick Dams. All available men working steadily were unable to keep the rack clean, and two tripods washed out near the right bank on the night of November 16. On November 17 a crew of men worked all day in an attempt to remove the trash, but with no success as water pressure held the debris so tightly against the pickets that much of it could not be moved by hand.

River discharges increased to 13,000 c.f.s. on the night of November 17, and on November 18 the trash had piled up higher than the rack in one place. The pressure was so great that the 8 by 8-inch stringers were bent and the rack became dangerous to walk on. Several more tripods then went out, leaving an isolated piece of rack near the right bank. This settled vertically several feet due to gravel washing out under the legs of the tripods.

Because of unstable gravel in parts of the river and extremely uneven bed rock in other areas, it may not be possible to maintain fish-tight racks without permanent sills on which to set the tripods.

Sacramento River Temperatures

On July 29, 1941, a recording thermometer was installed on the Balls Ferry bridge about 200 yards above the lower rack site. Maximum daily river temperatures were recorded from that date until October 25, 1941. The range was from 74°F. on July 31 to 48°F. on October 25. On September 18 the temperature dropped to 60°F., and except for a degree or two rise on several occasions, remained at or below that temperature until late October.

A temperature of 60°F. or less is considered suitable for holding fall-run salmon in the main river for natural propagation. On the basis of the 1941 temperature record, the main river racks could be closed off in late September and the fall-spawning plan placed in operation.

Transfer of Adult Salmon to Battle Creek

During July 1942, 166 adult salmon were transferred experimentally from the Sacramento River at Redding to the Battle Creek holding ponds. However, soon after the fish were released in the holding ponds at Battle Creek many of them died. The mortality of these fish may be attributed to severe changes in the stream when Battle Creek was diverted into a new channel during construction of the water supply canal for the Coleman hatchery and ponds. These changes completely nullified the validity of the experiment.

DEER CREEK STUDIES

A study of Deer Creek from May 1941 to June 1943 was conducted to determine:

1. The size and distribution of the natural run of salmon entering Deer Creek.
2. The reaction of fish transferred from the Sacramento River at Redding.
3. The mortality rate of natural and transferred fish during the period they spend in the stream preparatory to spawning.
4. The manner and extent of utilization of gravel spawning beds in the stream.
5. The beginning and end of the seaward migrations of salmon fry and the peaks of these migrations.
6. The annual range of daily maximum water temperatures.

In May 1941, a weir was constructed across lower Deer Creek to provide a place to count the native salmon run entering the stream. This weir was also used to prevent transferred fish from returning to the Sacramento River.

Counts of Natural Run Salmon, 1941, 1942, and 1943.

On May 20, 1941, a counting-board was installed in the weir in lower Deer Creek for the purpose of counting the native run salmon into the stream. From May 20 to July 6, 635 salmon were counted through the weir. The native run of salmon in Deer Creek is, however, larger than is shown by the 1941 count. Evidence of this is obtained from the 1939 salmon count in the Sacramento River where 37 percent of the run from April 17 to July 6 migrated upstream before May 20, the date that counting began in 1941.

The major part of the 1941 count was recorded from June 4 to June 15. The peak day was June 12 when 176 fish passed over the counting board. Salmon were seen moving upstream as late as July 6, 1941, and many more would, no doubt, have been counted through the weir if extremely high water temperatures (appendix table 16) had not caused considerable mortality of native run salmon on the riffles below the weir.

The 1942 count was begun on May 13 following the installation of the counting weir. From May 13 to July 2, 1,108 salmon were counted through the weir.

In May and early June 1942, all of the counting was done during the day, but after the middle of June the counting was done at night. The change from day to night counting was made when it was observed that the fish were reluctant to leave the deep holes below the weir during the day and would move upstream only when the water cooled in the late evening.

The highest count for a single day was on June 5 when 135 salmon passed through the weir. It is interesting to note that the peak days of both 1941 and 1942 were accompanied by a steady rise in water temperatures with the highest water temperature to date recorded on the peak day. On June 12, 1941, a stream temperature rise to 77°F. was coincident with the peak day of 176 fish. On June 5, 1942, a stream temperature rise to 68°F. was recorded on the peak day. This would indicate that a gradual rise in stream temperatures stimulates the fish to move out of the lower reaches of the creek to the cooler waters upstream. However, after the middle of June when very high water temperatures persist during the day, the salmon move upstream at night only.

Neither the 1941 nor the 1942 count is complete because the migrations started early at a time when excessively high water prevented the installation of the counting weir. Evidence of this was found on March 26, 1942, when three spring-run salmon were seen near the weir site and again during a heavy rain in early April, when 45 salmon were counted jumping over the Stanford-Vina irrigation dam in lower Deer Creek.

In 1943, the weir was installed on February 20, but high water necessitated its removal on three occasions between February 23 and May 1. For that reason, the 812 salmon counted in 1943 represent only a fraction of the total spring run. Many salmon escaped upstream without being counted.

The major portion of the 1943 count was made between April 13 and April 24 when 381 salmon or about 47 per cent of the total 1943 count passed through the weir (Table 4). This included the peak day of 178 salmon on April 22, 101 of which passed through the weir during the first hour it was open. That the 1943 spring salmon run in Deer Creek was smaller than in the two previous years is evidenced by the few fish counted in May and June 1943 as compared to the counts made during those two months in 1941 and 1942. Only 291 salmon passed through the weir in May and June 1943 as compared with 1,075 in 1942 and 629 in 1941 (Table 5). No fish were seen in the vicinity of the weir after June 16, 1943, while in both 1941 and 1942 counting was not discontinued until early July. Stream flows were approximately the same for all three years.

The salmon counts made during these three years appear to correlate upstream movements of large numbers of salmon with (1) an increased flow in the stream, (2) a gradual rise in stream temperature over a period of several days, and (3) very high daily water temperatures resulting in the migration of large numbers of salmon when the water cools at night.

Facilities Used for Experimental Transfer of Salmon

Temporary facilities for trapping salmon at Redding for experimental transfer to Deer Creek were installed in the Redding Dam in late May 1941. The trap consisted of two metal screen barriers anchored in the upper pool of the ladder forming a pool 7 by 9 feet in which the salmon could be held. Each barrier had an opening in the center in which a counting board could be fastened. The floor of the trap was a large wooden brail that could be raised and lowered as required. In trapping the fish, the opening in the upstream barrier was closed and the fish were counted into the trap over the counting board in the opening in the lower barrier. When a sufficient number had been trapped, the gate on the counting board was closed. A 500-gallon steel loading tank was then lowered into the fish ladder at the upstream face of the upper barrier with the opening of the tank facing that of the barrier. The brail bottom of the trap was lifted forcing the fish to swim into the tank. The size of the loads taken varied from 11 to 49 fish, depending on the number available in the ladder and their sizes. The loaded tank was then lifted from the trap to the waiting truck. The fish were released into the truck tank through a trap door in the bottom of the loading tank. The 65-mile trip to Deer Creek required about two hours.

The point of release at Deer Creek was located just above the counting weir which is three miles north of Vina, California. A short gravel spur was built from the main county road to a log bulkhead on the edge of the creek. A metal tube, two feet in diameter, made by attaching two pieces of half-round galvanized iron irrigation flume together, was used to release the fish from the tank truck to a holding box anchored in the stream. Appendix table 6 shows the daily numbers of fish transferred, the time of release into the stream, and analyses of the water both in the truck tank and in the stream.

Salmon Transfer Experiment

Over a period of 28 days, from June 3 to June 30, 1941, 920 salmon were transferred to Deer Creek from the Sacramento River at Redding. Of these, 488 were marked. The first 64 were marked by clipping the adipose fin and placing a red rubber band around the caudal peduncle. This method proved unsatisfactory, and was abandoned because the rubber bands either fell off or caused severe injuries. Of the remaining number, 245 were marked by clipping the adipose fin, and 179 were marked by cutting off a portion of the dorsal fin. The fish were anaesthetized[1/] before clipping the dorsal fins.

1/ The method used was suggested by Dr. F. F. Fish, Aquatic Biologist, U. S. Fish and Wildlife Service.

By the end of June, 68 of the 179 salmon marked in this manner had died. Although only 16 more of these fish were found dead by the end of August, it is believed by the observers that the mortality was actually greater as the section of the stream between the weir and the Deer Creek Irrigation Company Dam is divided into a labyrinth of side channels that made it virtually impossible to patrol completely enough to see and collect all the dead fish. None were found at any time in the canyon above the dam.

The total recovery of dead fish by the end of August was 284 (30.8 percent). These included the 84 anaesthetized salmon, previously mentioned, 62 with clipped adipose fins and 138 unmarked fish. The 138 unmarked salmon were believed to have been among those released into Deer Creek as most of them were found during or just shortly after the transfers. Therefore, when the first spawning activity was noted in late August, there may have been 247 fish with clipped adipose fins, 95 with clipped dorsal fins, and 294 unmarked salmon, or a total of 636 individuals still alive out of the 920 transferred to Deer Creek.

Observations on Holding Salmon in Deer Creek

From July 10 until the first week in September when spawning began, weekly trips up the canyon were made from the Deer Creek Irrigation Company Dam to Campbellville. The purpose of these trips was to observe, if possible, the movements of the marked fish, to recover and record all dead salmon, and to determine the lower limits of the stream used by the salmon during the hot months of July and August.

Because of poor visibility and the tendency of the fish to remain in deep pools, none of the marked fish was seen during the summer. Only four dead fish were recovered. Two of these were too badly decomposed to determine whether they had been marked. The other two were unmarked. After July 13, 1941, no salmon were seen in the section from the Deer Creek Irrigation Company Dam to a point eight miles upstream. Salmon reappeared in this section in the fall when stream temperatures began to drop and some were observed spawning in mid-October on riffles about 1-1/2 miles above the irrigation dam.

After September 10, when spawning began, until October 25, when spawning was completed, the creek was examined daily except for three periods of three days each. During these trips all dead fish were removed from the stream, and after recording the pertinent data, the carcasses were discarded.

Spawning Observations

The first activity preparatory to spawning was observed the last week in August near the lower falls. It consisted of spasmodic attempts at nest-building and general movements of the salmon from deep holes to the gravel spawning beds. No intensive nest-building was observed in this area until the first week in September. Nest-building in the Campbellville

section did not begin until the end of the first week in September, and another week passed before any activity was noted in the Apperson Ranch section. During the first week in October, when the water temperatures dropped in the section below Apperson's Ranch, nest-building began there. (See map for location of sections.)

The peak of spawning activity in each section, as shown by the numbers of dead fish recovered, ranged from the last week in September in the upper part of the creek to the middle of October in the lower part. There is a lag of several days between the peak of spawning and the peak of the number of dead fish recovered because both male and female salmon often live several days after they have completed spawning.

By the end of spawning season in late October 1941, 1,463 dead salmon had been recovered. Seventy-six, or approximately 5 percent, of these were too badly decomposed at the time of recovery to obtain any useful data from them (appendix table 8). Of the remaining 1,387, all but 2 percent had spawned completely. The greatest number of dead salmon was taken in the section of the stream from Campbellville to the lower falls. This was to be expected, as earlier observations of this section showed large concentrations of fish swimming in the deep holes. Among the 1,463 dead salmon recovered, were 13 marked fish, all of which lacked the adipose fin. Of these, 7 were males and 6 were females. One of these was recovered 1-1/4 miles below the lower falls and one at the Deer Creek Irrigation Company Dam. Five were found in the Apperson Ranch section, five in the Campbellville section, and one just below Wilson's Cove. Eleven had spawned completely; two only partially. This recovery of marked transferred fish indicates that salmon removed from the Sacramento River and transferred to Deer Creek will distribute themselves similar to native-run salmon and will spawn naturally in that stream.

Utilization of Spawning Areas

The number of salmon that entered Deer Creek in the natural run during the spring of 1941 plus the number that survived the transfer from the Sacramento River at Redding was approximately 7,000. This figure was obtained from a study of the extent of gravel areas used by spawning salmon in the stream.

The utilization study consisted of mapping all riffle areas suitable for spawning and determining the extent to which each riffle area had been disturbed in nest-building. In addition to this, all individual nests that did not occur in the main riffle areas were recorded, as well as unused but potential nest areas in isolated gravel patches. The average nest area was estimated at 40 square feet, a figure based on actual measurement of 87 nests (appendix table 11). Starting at the lower falls and proceeding downstream, the riffles were numbered in order beginning with number 1, located about 200 yards below the lower falls, and ending with number 77, 1-1/2 miles above the Deer Creek Irrigation Company Dam.

The total number of nests observed during the study was 2,704 (appendix table 12). If it is assumed that only one female used a nest and that the ratio of 1.65 males to 1 female[2/] holds for the entire population in the stream, the total number of salmon in Deer Creek during the year was in the neighborhood of 7,000 (2.65 times 2,704 equals 7,165). It was the opinion of the observers that about two-thirds of the available gravel beds in the stream were used by the spawning salmon.

Although an estimated 7,000 spring salmon spawned in Deer Creek in 1941, it is recommended that 10,000 spring-run salmon be transferred from the Sacramento River to Deer Creek in 1943. Since only two-thirds of the available spawning gravel was used in 1941 and an additional 4 to 5 miles of stream are being made accessible to salmon by the lower falls fishway, it is believed that if 10,000 are transferred, this number would not overcrowd the stream. Careful observations of Deer Creek will be made after the salmon have been transferred to determine whether or not this number should be increased or decreased. These observations will aid in arriving at the most suitable number of salmon that Deer Creek can accommodate.

Salmon transfers from Sacramento River at Keswick Dam to Deer Creek, 1943.

The transfer of adult chinook salmon to Deer Creek from the Sacramento River was begun on June 1, 1943, following the completion of temporary trapping and lifting facilities in Keswick Dam near Redding, California. A total of 5,245 salmon was transferred from the Sacramento River and released into Deer Creek during the period from June 1 to 29 (Table 13). Of these only 110 were marked by clipping the adipose fin.

Seven trucks, previously described, were used to haul the fish to Deer Creek. The number of fish in each load varied with the abundance of fish in the trap and the number of coarse fish (mostly suckers) it was necessary to include in each load. It was impossible to segregate them from the salmon during loading operations. Although the number of salmon in the loads ranged from 20 to 49, the average load was 39 salmon per truck.

While enroute the water temperature in the truck tanks was lowered to approximately 50°F. by circulating the water through a compartment filled with 1,500 pounds of ice. When the trucks reached Deer Creek, the tank water was slowly tempered by pumping water from the creek into the truck tank. The fish were released when the water temperature in the tank was within two or three degrees of that in the creek. Analyses were made of the samples of the tank water on arrival at the dump site to determine the oxygen content. Results of these analyses made it possible to determine the adjustments necessary to maintain an oxygen content near saturation in the tank. Failure of the aerating apparatus to function properly resulted in the loss of six loads of salmon during the first week of hauling. When this was remedied, the loss of salmon in the tank was negligible for the remainder of the transfers.

[2/] The ratio of 1.65 males to 1 female was the proportion found between the sexes of 1,387 dead salmon examined on the spawning beds at the completion of spawning in 1941.

Among the early fish transferred to Deer Creek were many winter run salmon. These fish were very ripe and on several occasions deposited eggs in the truck tank while enroute from Keswick Dam. Other winter run salmon engaged in spawning activity near the dump site as soon as they were released into the creek. Between June 1 and July 15, 52 ripe salmon and 7 spawned out salmon were recovered dead in the section of the stream from the dump site to the mouth of the canyon. Of the 52 ripe salmon found, 49 were females and 3 were males, while 4 of the spawned out salmon were females and 3 were males. In all probability this number includes some of the natural winter run salmon known to be present in Deer Creek.

A long delay in the completion of trapping facilities in Keswick Dam resulted in serious losses to the 1943 spring run. Many salmon confined below the dam during this delay were so badly bruised by jumping against the rocks and base of the dam that they died before the transfers began. An additional 375 salmon died in the brail and sweep chambers of the Keswick trap during the transfers in June. This loss suffered by the 1943 spring run may have a serious effect on future cycles of this year class.

By July 21, 1943, the total mortality of salmon transferred was 1,273 (table 13) or 24.4 percent of the entire number transferred. Of this number 831 were in good enough condition when recovered to examine thoroughly and determine the sex and nature of the injuries. Sixty-three percent, or 525, were females and thirty-seven percent, or 306, were males. The remaining 442 fish included 258 that died in the tanks and 184 that were too decomposed when recovered to examine for data.

All of the dead salmon recovered in Deer Creek, in the truck tanks, and off the weir were examined to determine, if possible, the cause of their death. As previously mentioned, severe injuries sustained by jumping against the rocks and the base of Keswick dam apparently caused the death of most of the transferred salmon. The injuries consisted of large bruises and abrasions on the body, torn or frayed fins, deep gashes on the head and snout, eyes missing, and the lower jaw badly torn. When the lower jaw was badly torn, as it was in many instances, the ventral aorta was severed and the fish bled to death. In addition to the injuries, the gills on most of the salmon were infested with copepods and presumably, Bacterium columnaris.

Losses in the truck tank before the fish arrived at Deer Creek were almost entirely due to low oxygen content in the water. The large number of suckers present in each of the first loads seriously depleted the amount of oxygen available. The aerators were run at full speed to compensate for the oxygen utilized by the scrap fish, and the increased oxygen supply greatly reduced the losses in the tank.

After June 8, trips were made almost daily from the dump site to the mouth of the canyon, a distance of 6-1/2 miles, until observations on July 19 showed that all of the salmon had moved out of this section

and into the cooler waters farther upstream. On these trips all dead salmon were removed from the creek, examined, and disposed of. On June 23 one trip was made about three miles into the lower part of the canyon. On this trip one marked salmon was observed swimming upstream approximately 10 miles above the dump site.

On July 6, two members of the field crew made an observation trip downstream through the lower part of the canyon from Campbellville to the mouth of the canyon, a distance of about 20 miles. Salmon were observed in all the deep holes for the first ten miles below Campbellville. One dead salmon was recovered about 6 miles below Campbellville. The injuries that apparently caused the death of this salmon were characteristic of those sustained by most of the transferred fish. Two more salmon, undoubtedly transferred fish, were recovered about 5 miles farther downstream.

Very few live salmon were seen in the last five miles of the canyon, indicating that the majority of natural and transferred salmon had sought the cooler waters of upper Deer Creek. One live marked salmon, in good condition, was observed about 6 miles above the mouth of the canyon, or approximately 13 miles above the point where it had been released into the creek.

From July 12 to 15 an observation trip was made of the upper part of the canyon from the lower falls to Polk Springs. This section is about 9 miles long and begins about 30 miles above the point of release on lower Deer Creek. No salmon could be seen in the upper portion of this section, but many salmon were observed in the deep holes above Polk Springs. Because of the depth and turbidity of the water, it was impossible to determine whether or not the fish observed were natural or transferred salmon. All appeared to be in excellent condition.

Seaward Migrant Chinook Salmon in Deer Creek, 1941, 1942, and 1943

A study of the seaward migration of chinook salmon fry in Deer Creek was begun in November 1941. The purpose was to determine as closely as possible the earliest date the progeny of the spring and fall run salmon start their seaward migrations and when the peaks of these migrations occur. Parallel fyke net studies made in the Sacramento River are to be used to judge the optimum time for liberating hatchery fish. It will also aid in determining what steps may be necessary to protect seaward migrants at diversion ditches.

The equipment used consisted of two fyke nets[3/] and one seaward-migrant trap patterned after those employed in similar studies at Bonneville Dam, Oregon.

3/ The fyke nets were made as follows: A frame of 1/2-inch galvanized pipe, four feet square, formed the opening with two similar frames, two feet square - one where the net tapered to the tunnel entrance and the other holding the shape of the net near the bag. The webbing used had a 1/2-inch stretch mesh and was attached to the frames with a tunnel leading into the bag. The bag was closed by means of a puckering string. No wings were used.

One fyke net was fished every night from November 15 to the end of December 1941, when flood waters prevented further operations until the middle of January 1942. During this period only two young salmon were caught. Since eyed eggs and yolk sac fry were dug from a spring run salmon nest at Polk Springs on November 28, 1941, a few early seaward migrants may be expected in December.

Fishing by fyke net was resumed on January 14, 1942, and at the end of the month, the trap was completed and added to the fishing equipment. The trap and both fyke nets were fished from February to April. Following the high water in early April, only one fyke net was operated until fishing was discontinued in July.

Most of the fishing was done at night. Several attempts were made to obtain migrants by day fishing in both clear and muddy water but with no results. On three occasions, March 11 and 13, and April 4, 1942, when night fishing results were exceptionally good, day fishing efforts failed to capture a single migrant. On all three days the water was muddy as a result of heavy rainfall.

The numbers of fry obtained in the nets and trap appeared to be correlated to some extent with the prevailing weather. A comparison of weather conditions and numbers of fry taken on various days indicates a tendency of the fry to migrate in greater numbers during, or shortly after, a rainfall. From March 11 to 15 (table 14), inclusive, 94 fry were taken during heavy rain and snow squalls. Accompanying the inclement weather was a drop in water temperature from 55°F. on March 9 to 43°F. on March 14. On March 16 the weather cleared; the stream temperature rose to 53°F.; and no great numbers of fry were taken until March 24, when rain again fell. Then on April 4 when heavy rains raised the creek to flood stage, 19 fry were taken in six hours of fishing from 6:00 P.M. to midnight. On April 10 rain fell during the night and ten fry were taken in one net. Toward the end of the migrations, this correlation did not always hold true, but the catches of salmon fry in January, February, March, and April indicated some relationship between rainfall and fry migrations.

Measurements of 343 migrants showed a range from 30 mm. to 67 mm. with one at 95 mm. The mode was 34 mm. and the mean 39 mm. Of the 343 migrants captured in Deer Creek, only seven measured more than 44 mm., indicating that the fry were migrating almost immediately after emerging from the gravel. In several individuals the yolk sac was not entirely absorbed.

The seaward migrants taken in December, January, and early February were probably from spring salmon which spawn in September and October. The first seaward migrants[4] of fall run salmon were taken in the fyke

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4/ Close examination of these fry placed them between two sample groups of fall salmon fry taken at the Battle Creek hatchery on February 2 and 20, 1942.

nets on February 11, 1942. They were two fry with the yolk sacs only partially absorbed. This was the only apparent means of distinguishing between the fry of the two migrations. Inasmuch as the yolk sacs of the spring salmon progeny in Deer Creek are entirely absorbed by early February, there is little doubt that the two fry with partially absorbed yolk sacs were among the first seaward migrants from the 1941 fall run salmon. As the migrating season progressed, it became increasingly difficult to separate the two migrations except in a few cases where there was a marked difference in size of the fry. For example, on April 24 two fry were taken; one of them measured 37 mm. and the other 60 mm.

No definite peak in seaward migration was observed in January or February 1942. Between January 16 and 21, fourteen salmon fry were captured. This was the largest number taken at any time until March 9 to 15, when a peak catch of 109 fry was recorded during that period. Following this peak there were several days on which fairly large catches were made but at no time were there large numbers on successive days. Fyke net fishing continued until July 3, 1942, but no fry were taken after June 6. The March peak closely coincides with observations made by Hatton (1942), who recorded a peak migration in the Sacramento River near Sacramento City on March 20 to 25, 1939. Allowing ten miles per day (Rutter, 1902) these fish could easily have reached the vicinity of Sacramento on the corresponding dates in 1942.

Since liberations of fall run fry were made from the Battle Creek and Mill Creek hatcheries on or near March 10, 1942, it would indicate that the peak migration in Deer Creek from March 9 to 15 was made up mainly of the progeny of fall salmon.

Fyke net operations in 1943 did not begin until February 10. For that reason the seaward migrant catch was no doubt made up mainly of progeny from 1942 fall run salmon inasmuch as the 1942 seaward migrant catch records show the first fall run salmon progeny were taken in the fyke net on February 11 of that year.

Throughout most of the 1943 season only one fyke net was operated. The seaward migrant trap, used successfully for a part of the 1942 season, was tried late in the season but without success. All fishing was done at night. Only 99 migrants were taken in 1943 as compared with a catch of 346 in 1942. The peak of the 1943 seaward migration came during the first week of March when 17 fry were taken between the first and the fifth of that month. The fyke net could not be fished from March 6 to 12 because of flood waters. Had fyke netting been possible during this period, it is probable that a peak catch comparable to the one made between March 9 and 15, 1942, would have resulted. After the peak movement there were no large catches made on successive days. However, there were five migrants taken on March 30 and six migrants on both April 28 and May 4. (Table 15).

Again, as in 1942, downstream movements of the salmon fry were correlated, to some extent, with the prevailing weather conditions. The peak movement in early March was accompanied by cloudy and rainy weather. The catches of six migrants on both April 28 and May 4 were made during nights on which considerable rain fell. Similarly, the catch of six migrants on February 24 was accompanied by showers during the night.

The measurements of the 99 fry which constituted the 1943 catch ranged from 30 mm. to 75 mm. with a mode of 37 mm. and a mean of 43 mm.

Water Temperatures 1941 to 1942

Daily water temperatures were taken at the counting weir on Deer Creek from May 20 to November 24, 1941, and from January 30 to July 3, 1942. The temperatures were recorded with a hand thermometer. These were taken each day about 4 p.m. when near maximum temperatures could be obtained. At this point on Deer Creek a range of 45°F. to 86°F. was recorded in 1941, and a range of 43°F. to 83°F. in 1942.

On July 3, 1941, a thermograph was installed at Campbellville, about 25 miles upstream from the weir, and remained there until October 22, 1941. Maximum temperatures occurred each day at about 4 p.m. and ranged from 48°F. to 70°F. Water temperatures were recorded at random along Deer Creek from the Deer Creek Irrigation Company Dam to the lower falls from July to November 1941. In upper Deer Creek from the lower falls to Polk Springs the temperature range was 43°F. to 67°F. In the area extending from Polk Springs to Campbellville, the range was 41°F. to 70°F., and between Campbellville and the irrigation dam, 48°F. to 77°F.

On several occasions salmon were observed in deep pools during the summer in parts of the stream where surface temperatures were as high as 73°F. No salmon were seen in the section of lower Deer Creek where the temperatures in July, August, and September varied between 74°F. and 86°F.

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APPENDIX TABLE 1

Salmon counts at A.C.I.D. Dam on Sacramento River at Redding, California

	1937*			1938**		
Day	Aug.	Sept.	Oct.	Sept.	Oct.	Nov.
1		5	298		19	139
2		3	4		42	59
3		3	474	6	61	10
4		6	192	3	184	
5		2	108	1	173	
6		2	90	0	179	
7	1	8	113	7	155	
8	2	4	191	3	118	
9	2	6	235	5	117	
10	1	7	393	2	116	
11	1	5	1,196	2	157	
12	2	6	984	3	89	
13	4	9	1,026	3	75	
14	2	6	857	3	187	
15	2	15	589	11	659	
16	2	21		6	233	
17	1	52		10	116	
18	0	38		5	259	
19	0	28		3	766	
20	0	31		13	225	
21	0	23		11	254	
22	1	29		7	201	
23	0	15		15	394	
24	0	11		10	385	
25	0	21		9	384	
26	0	63		17	1,683	
27	1	147		11	1,740	
28	1	139		28	2,453	
29	1	132		75	1,135	
30	2	167		9	364	
31	1				482	
Totals	27	1,004	6,750	278	13,399	208
Season Totals		7,781			13,885	

*Counts made by California Division of Fish and Game as fish leaped over flash-boards.

**Counts prior to October 27 (and 1,334 on that date) were made by Bureau of Reclamation as the fish passed through the counting weir in the fish ladder. After that date they were counted as they leaped over the dismantled dam.

APPENDIX TABLE 1 Continued

Salmon counts at A.C.I.D. Dam on Sacramento River at Redding, California

1 9 3 9

Day	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1		8	81	39	21	0	162	146	30
2		32	35	9	11	0	160	167	45
3		19	105	9	2	2	58	127	35
4		25	133	10	4	0	68	113	29
5		16	37	146	1	5	179	61	39
6		17	16	50	1	3	91	105	20
7		2	30	39	2	6	262	80	30
8		21	196	34	4	16	259	120	32
9		28	143	9	1	38	94	94	
10		73	94	11	0	28	192	112	
11		308	117	8	0	66	283	69	
12		80	197	12	0	142	379	100	
13		86	151	13	0	109	268	122	
14		85	145	5	1	87	252	74	
15		108	71	3	0	80	286	78	
16		261	14	4	0	73	352	80	
17	5	153	20	4	4	68	413	550*	
18	9	243	25	6	10	67	452	365	
19	6	100	9	3	4	98	393	139	
20	14	38	29	3	0	209	216	77	
21	42	77	40	3	3	198	431	64	
22	66	52	74	2	2	296	474	33	
23	21	41	57	7	7	301	443	**	
24	37	28	94	4	0	472	785	35	
25	17	78	92	7	0	397	152	48	
26	19	90	41	5	3	243	142	45	
27	32	72	44	5	0	150	237	52	
28	40	127	31	4	0	231	303	39	
29	40	107	25	3	1	225	435	33	
30	39	99	30	11	1	183	326	52	
31		137		55	2		318		
Totals	387	2,611	2,176	523	85	3,793	8,365	3,180	260

Season total 21,894

*Dismantling of dam begun and fish counted from both ends of the dam until December 8.

**No count.

APPENDIX TABLE 1 Continued

Salmon counts at A.C.I.D. Dam on Sacramento River at Redding, California

	1940					
Day	May	June	July	Aug.	Sept.	Oct.
1		149	11	68	8	450
2		176	11	33	5	361
3		173	16	39	55	357
4		333	10	25	92	247
5		453	6	29	23	416
6		500	11	25	26	239
7		352	4	25	29	410
8		296	5	18	33	259
9		292	10	24	31	332
10		640	7	5	81	436
11		542	47	3	56	415
12		304	49	6	123	1,229
13		403	6	2	96	812
14		545	4	24	98	240
15		413	9	17	107	753
16	72	366	7	89	135	1,642
17	88	230	76	58	191	470
18	35	139	27	24	119	935
19	55	94	9	12	132	2,094
20	80	12	4	14	71	1,094
21	255	49	6	7	190	655
22	267	91	2	6	118	1,465
23	232	32	5	3	170	1,966
24	190	42	24	4	198	1,365
25	260	24	175	0	141	2,522
26	200	27	182	10	283	415*
27	291	17	129	8	249	847*
28	260	43	70	3	266	866*
29	322	43	70	13	148	558*
30	322	11	97	9	163	587*
31	160		70	15		509*
Totals	3,091	6,791	1,157	618	3,437	25,146
Season total	40,248					

*Count made by a man at each end of dam as flashboards were being removed during daylight only.

APPENDIX TABLE 1 Continued

Salmon counts at A.C.I.D. Dam on Sacramento River at Redding, California

	1941					
Day	May	June	July	Aug.	Sept.	Oct.
1		19	197	23	26	423
2		157	339	18	41	1,197
3		424	529	15	74	598
4		194	217	13	39	521
5		281	204	62	36	366
6		79	135	78	52	191
7		81	137	107	83	289
8		14	179	73	91	498
9		26	828	57	102	873
10		26	605	53	140	306
11		117	459	40	140	1,053
12		390	308	41	46	629
13		1,122	62	34	62	347
14		662	270	49	10	477
15		239	142	55	19	2,314
16		633	697	67	55	1,377
17	5	232	173	18	44	2,243
18	7	211	110	27	155	1,081
19	2	182	111	58	94	1,029
20	4	234	48	81	60	420
21	20	129	62	61	22	843
22	29	636	68	35	41	855
23	59	258	56	34	58	1,619
24	62	398	54	33	150	1,995
25	44	224	29	30	83	923
26	191	244	41	42	236	344
27	15	177	36	83	81	798
28	48	229	43	32	119	458
29	98	322	21	21	88	791
30	37	207	25	41	262	776
31	26		32	22		299
Totals	647	8,147	6,217	1,403	2,509	25,933
Grand total	44,856					

APPENDIX TABLE 1 Continued

Salmon counts at A.C.I.D. Dam on Sacramento River at Redding, California

	1942					
Day	May1/	June1/	July2/	Aug.	Sept.	Oct.
1		77	77	10		114
2		46	60	*		161
3		76	145	7		89
4		73	212	8		106
5		21	125	12		127
6		19	29	*		143
7		*	45	5	17	127
8		14	35	*	64	94
9		35	27	*	38	296
10		33	22	8	11	319
11		23	14	**	4	325
12		23	11		10	81
13		37	*		9	51
14	37	30	4		13	38
15	36	37	8		17	8
16	41	38	6		11	
17	50	28	28		22	
18	123	31	26		32	
19	152	34	*		13	
20	141	24	12		18	
21	64	42	49		29	
22	288	49	17		40	
23	149	52	10		678	
24	*	81	20		165	
25	*	24	15		103	
26	43	18	9		135	
27	18	20	9		113	
28	22	9	9		164	
29	35	6	10		75	
30	36	17	3		82	
31	24		6			
Totals	1,259	1,017	1,043	50	1,864	2,079
Season total	7,312					

*No count

**Counting discontinued until September 7

1/Due to high water majority of fish counted were those which were seen to pass over the first three bays of the dam.

2/Counting through ladder from July 1 to October 15, 1942.

Appendix Table 2

Counts of salmon at two Deer Creek Stations - May, June, July, 1941

Date	Deer Creek Weir: No. of salmon	Deer Creek Weir: Water temp.	Deer Creek Irrigation Co. Dam: No. of salmon	Adipose marked	Dorsal marked	Water temp.
May 20	3	66				
21	6	67				
22	20	70				
23	55	70				
24	46	68				
25	18	67				
26	17	62				
27	9	64				
28	5	60				
29	12	60				
30	3	61				
31	32	63				
June 1	1	63				
2	8	64				
3	2	64	1			60
4	86	67	7			66
5	9	66	43			62
6	15	66	2			62
7	8	65	17			62
8	3	67	6			64
9	32	70	16	1		64
10	2	74	3			64
11	1	74	12	2		70
12	176	77	8	1		72
13	26	76	56	4		70
14	1	72	18	5		68
15	13	72	5	1		70
16	3	68	21	5		66
17	4	70	12	4		66
18	3	72	24	4		66
19	0	69	19	6		66
20	6	72	10	2		68
21	0	70	18	10		68
22	0	64	6	0		64
23	0	71	7	2		68
24	0	67	5	0		64
25	0	69	0	0		66
26	0	70	1	0		64
27	0	70	0	0		66
28	0	73	1	0		68
29	1	76	9	3	2	69
30	0	79	3	1	1	71
July 1	0	80	6	2	3	72
2	3	78	8	2	2	74
3	0	79	4			74
4	0	80				
5	0	82	1			66
6	6	82	1			76
7	0	84	1			75
8	0	82	0			76
9	0	84	0			77
10	0	78	0			76
11	0		0			
Grand Totals	635		351	55	8	

APPENDIX TABLE 3

Counts of salmon in Deer Creek Station for 1942

Date	Daily count of salmon	Grilse	Trout	Suckers	Carp
May 13	5	2	1		
14	12	3			
15	8	2		1	
16	30	7	1		
17	2	1			
18	64	11	25	31	
19	23	5	11	4	
20	39	6	16	10	
21	95	37	26	24	
22	12	0	4	3	
23	40	7	5	4	
24	15	3	6	1	
25	24	5	4	3	
26	58	6			
27	12	4	1		
28	3	2			
29	0	0	1		
30	3	1	1	17	
31	0	0		15	
Totals	444	102	102	113	
June 1	9	3		23	
2	12	2		15	1
3	4	1		3	
4	5	0			
5	135	26	15	26	3
6	11	0	3	6	1
7	0	0		4	
8	0	0	1		
9	5	4		3	
10	22	3	2	11	10
11	5	1	1		
12	2	0	1	2	2
13	1	1			
14	46	7		24	3
15	67	8	5	15	2
16	38	7	1		
17	28	7	5		2
18	17	6	1	1	3
19	6	3		3	
20	12	4			1
21	9	2			
22	59	20	3	6	
23	24	5	1	1	
24	30	6	3	4	
25	16	5		3	
26	6	1			
27	1	1			
28	8	2			
29	17	5	1	1	
30	36	11		3	
July 1	24	5		1	
2	9				
Totals	664	146	43	155	28
Grand Totals	1,108	248	145	268	28

APPENDIX TABLE 4

Salmon counts, Deer Creek, 1943.

Date	Salmon	Grilse	Steelhead upstream	Steelhead downstream	Trout
Feb. 20	0	0	1		
21	0	0			
22	1	0	18		
Feb.23 to Mar.1	No count--high water				
2	1	0	2		
3	0	0	4		
4	0	0	11		
5	0	0	16		
6-19	No count--high water				
20	0	0	2		
21	0	0			
22	1	0	1		
23	0	0	8		
24	0	0	4		
25	0	0	12		
26	0	0	4	1	
27	14	1	8	1	
28	2	1	2	1	
29	52	9		2	
30	1	0			
31	0	0	2	1	
Totals	72	11	95	6	
April 1	0	0	2		
2	1	1		6	
3	0	0		1	1
4	0	0	1		
5	32	7		11	
6	0	0	1	1	
7	0	0	1	4	
8	35	9	5	9	
9	0	0			
10	0	0		1	
11	0	0			
12	0	0	3		
13	11	4		4	
14	34	12		2	2
15	72	17		19	
16	21	5		5	
17	6	2		2	
18	0	0			
19	3	1		2	
20	0	0			
21	27	7		10	
22	178	43		11	
23	2	1			
24	27	7		11	
25	0	0	1	1	1
26	0	0		2	
27	0	0		1	
28-30	No count--high water.				
Totals	449	116	14	103	4

APPENDIX TABLE 4 (Continued)
Salmon counts, Deer Creek, 1943.

Date		Salmon	Grilse	Steelhead upstream	Steelhead downstream	Trout
May	1	No count--high water				
	2	2	1			
	3	0	0		9	3
	4	1	0			
	5	0	0		1	1
	6	24	11		1	1
	7	7	2		3	
	8	0	0			
	9	5	1			
	10	4	3		1	
	11	0	0		2	
	12	0	0		27	
	13	1	0		5	
	14	0	0		4	
	15	0	0		9	
	16	0	0			
	17	2	0		2	
	18	3	0		7	
	19	3	0		6	
	20	8	3		6	
	21	1	1		3	
	22	0	0		12	
	23	21	4			
	24	58	14		25	1
	25	18	6			
	26	15	4		18	
	27	12	3		11	
	28	1	0			
	29	1	0			
	30	2	1			
	31	1	0		4	
Totals		190	54		156	6
June	1	63	27		19	
	2	26	13		2	
	3	0	0			
	4	0	0			
	5	0	0			
	6-10	No count--No sign of any upstream migrants				
	11	3	0			
	12	8	6			
	14-15	No count--No sign of any upstream migrants				
	16	1	0			
Totals		101	46		21	
Grand Totals*		812	227	109	286	10

*In addition to the fish listed above there were 54 suckers, 2 squawfish, and 2 carp.

APPENDIX TABLE 5

Summary of Deer Creek Salmon Counts by Days.

	1941			1942			1943				
Day	May	June	July	May	June	July	Feb.	Mar.	Apr.	May	June
1		1	0		9	24		-	0	-	63
2		8	3		12	9		1	1	2	26
3		2	0		4	0		0	0	0	0
4		86	0		5			0	0	1	0
5		9	0		135			0	32	0	0
6		15	6		11			-	0	24	0
7		8			0			-	0	7	0
8		3			0			-	35	0	0
9		32			5			-	0	5	0
10		2			22			-	0	4	0
11		1			5			-	0	0	3
12		176			2			-	0	0	8
13		26		5	1			-	11	1	0
14		1		12	46			-	34	0	0
15		13		8	67			-	72	0	0
16		3		30	38			-	21	0	1
17		4		2	28			-	6	2	
18		3		64	17			-	0	3	
19		0		23	6			-	3	3	
20	3	6		39	12		0	0	0	8	
21	6	0		95	9		0	0	27	1	
22	20	0		12	59		1	1	178	0	
23	55	0		40	24		-	0	2	21	
24	46	0		15	30		-	0	27	58	
25	18	0		24	16		-	0	0	18	
26	17	0		58	6		-	0	0	15	
27	9	0		12	1		-	14	0	12	
28	5	0		3	8		-	2	-	1	
29	12	1		0	17		-	52	-	1	
30	3	0		3	36		-	1	-	2	
31	32	0		0				0		1	
Totals	226	400	9	444	631	33	1	71	449	190	101
Grand Totals		635			1,108				812		

- Dash denotes rack removed from creek because of high water.

APPENDIX TABLE 6

Salmon transfers, Redding to Deer Creek, June 1941

Date	No. fish trans.	Time of arrival p.m.	Time of release p.m.	Tank temp. arrival °F	Tank temp. release °F	Stream temp. °F	O2 Content tank p.p.m.	O2 Content stream p.p.m.	pH tank	pH stream
June										
3	20	1:55	2:40	53	62	64	10.2			
4	11	7:15	8:00	54	64	66	10.2			
5	36	2:35	3:20	53	65	68	9.0	8.2		
6	34	1:20	2:05	54.5	64.5	67	9.3	9.2	7.2	
6	27	9:30	10:15	55	58	60	10.5	9.9	7.0	
7	29	3:20	3:45	55	66	68	9.6	8.7	7.2	
9	13	9:10	10:00	55	62	65	10.0	8.9	6.6	
10	12	5:35	6:10	60	72	74	10.2	8.3	7.2	
11	49	12:25	12:55	57	72	74	8.7	8.5	6.6	7.4
11	48	9:35	10:00	58	70	72	8.4	8.3	6.6	7.4
12	33	6:00	6:32	58	76	78			6.8	7.3
13	36	3:20	3:55	58	76	79	10.2	8.6	6.7	7.5
14	47	3:30	4:00	58	74	76	9.0	8.0	6.6	7.6
15	40	3:45	4:05	56	73	75	8.1	8.2	6.6	6.2
16	43	12:55	1:20	58	68	69	9.1	8.7	6.7	7.5
16	44	8:30	9:07	57	65	67	9.1	8.9	6.6	7.2
17	40	2:40	3:30	56	70	72	8.3	8.5	6.5	7.0
18	23	4:25	4:57	56	69	73	9.6	8.3	6.9	7.5
19	31	2:25	2:45	56	72	74	4.8	8.4	6.7	7.2
20	41	8:00	8:40	57	67	69	9.6	8.5	6.7	7.3
21	12	4:35	5:15	55	70	72	7.8		7.1	7.5
22	30	4:20	5:10	59	67	70	10.1	8.7	6.8	7.5
23	24	2:05	3:12	52	70	73	9.9	8.4	6.8	7.0
24	34	3:00	3:48	53	66	68	9.5	9.3	6.8	7.3
25	20	2:30	3:05	55	68	70	9.3	8.8	6.9	7.3
26	20	1:50	2:25	54	70	72	9.3	8.8	6.9	7.3
27	35	3:40	4:20	56	71	73	9.4	7.0	6.8	7.5
28	29	1:50	2:25	56	71	74	9.8	8.5		7.5
29	27	2:35	3:10	58	74	77	9.3	8.2		7.5
30	32	2:34	3:05	60	77	79	8.5	8.0	6.9	7.2

APPENDIX TABLE 7

Mortality of transferred fish recovered, Deer Creek, June - August 1941

Date	Trans-ferred fish	Clipped adipose fin	Clipped dorsal fin	Mortality of clipped adipose fin	Mortality of clipped dorsal fin	Mortality of unmarked fish	Total mortality
June							
1							
2							
3	20						
4	11						
5	36	36*		1			1
6	61						
7	29	28*				1	1
8							
9	13	13					
10	12					3	3
11	97	49		16		1	17
12	33	18		3			3
13	36			1		18	19
14	47	47		4		15	19
15	40			2		2	4
16	87	43		2		1	3
17	40	40		1		1	2
18	23			2			2
19	31			2		24**	26
20	41			2			2
21	12		12			1	1
22	30			1		29**	30
23	24		24		7	1	8
24	34		33	2	4	1	7
25	20		20	1	12	2	15
26	20		20		4		4
27	35	35			2	2	4
28	29		28	3	8	2	13
29	27		13		13	14	27
30	32		29	2	18		20
Totals	920	309	179	45	68	118	231
July							
1				3		1	4
2					1	1	2
3					1	2	3
4					1		1
5				1	1		2
6				1	5	2	8
7							
8						1	1
9				4	4		8
10							
11							
12				2	1	4	7
13					1	2	3
14				2		2	4
15-31				3	1	5	9
Grand Totals	920	309	179	62***	84	138	284

*Also tagged with red band around caudal peduncle.

**These fish were killed in transit.

***One salmon with clipped adipose found dead on August 29.

APPENDIX TABLE 8

Numbers[1] of salmon recovered after spawning, Deer Creek
September 12 to October 24, 1941

Section	Male	Marked male	Female	Marked female	Decom-posed	Total
Lower Falls to Wilson Cove	209		159	1	16	385
Wilson Cove to Polk Springs	174		114	1	7	296
Polk Springs to Murphy's Cabin	125		93		40	258
Murphy's Cabin to 16-Mile Mark	238	1	120	4	11	374
16-Mile Mark to Upper Dam	110	6	32		2	150
Totals	856	7	518	6	76	1,463

[1] Includes marked salmon as follows:-

Lower Falls to Wilson Cove------10-4-41 Female with clipped adipose
Wilson Cove to Polk Springs-----10-8-41 " " " "
Murphy's Cabin to 16-Mile Mark-- 9-17-41 " " " "
9-18-41 1 ♂ and 2 ♀ with clipped adipose
16-Mile Mark to Upper Dam------- 9-24-41 Male with clipped adipose
10- 4-41 " " " "
10- 5-41 " " " "
10-23-41 2 males with " "
10-24-41 Male with clipped adipose

APPENDIX TABLE 9

Sex ratio of salmon recovered after spawning, Deer Creek
September--October, 1941

Section	Male	Female	Total fish of determined sex
Lower Falls to Wilson Cove	209	160	369
Wilson Cove to Polk Springs	174	115	289
Polk Springs to Murphy's Cabin	125	93	218
Murphy's Cabin to 16-Mile Mark	239	124	363
16-Mile Mark to Upper Dam	116	32	148
Totals	863	524	1,387

APPENDIX TABLE 10

Marked fish recovered Deer Creek - 1941

Date of recovery	Where recovered	Type of mark	Sex	Standard length cm.	Extent to which fish had spawned
Sept.					
17	3/4 mile above Campbellville	Clipped adipose	F	61.0	Spawned out eggs left - 147
18	1/2 mile below Campbellville	"	F	55.8	Partially spawned Approximately 1,000 eggs left
18	1/2 mile below Campbellville	"	M	38.1	Spent
18	1/2 mile below Campbellville	"	F	62.0	Spawned out eggs left - 123
24	3/4 mile below 16-Mile Mark	"	M	59.0	Spent
Oct.					
4	Wildcat Creek	"	M	48.3	Spent
4	1-1/4 mile below Lower Falls	"	F	67.2	Spawned out eggs left - 11.
5	1/4 mile above Steamboat Mt.	"	M	50.8	Partially spent
8	1-3/4 mile below Wilson Cove	"	F	71.1	Spawned out. No eggs left.
22	1-1/2 miles above Campbellville	"	F	67.2	Spawned out. Eggs left - 6.
23	1/4 mile below 16-Mile Mark	"	M	55.9	Spent.
23	1/2 mile above Appersons	"	M	77.5	Spent.
24	Deer Creek Irr. Co. Dam	"	M	66.0	Spent.

APPENDIX TABLE 11

Measurements of 87 salmon nests in Deer Creek

1941		
Square feet	Square feet	Square feet
52	37	36
38	55	42
60	55	45
53	45	36
45	40	38
45	50	40
45	45	33
42	64	40
40	34	42
55	64	45
20	54	40
24	48	42
40	46	36
45	60	45
45	28	36
33	60	38
16	50	40
14	57	33
35	42	40
30	38	40
24	44	36
30	60	22
39	40	66
40	54	52
45	60	45
35	42	42
64	60	45
12	50	28
30	60	55
		3,716

Average - 42 sq. ft.

APPENDIX TABLE 12

Observed nests in Deer Creek, October, 1941

Section of Deer Creek	Actual nests on riffles	Isolated nests	Total actual nests
Lower Falls to Wilson Cove	431	150	581
Wilson Cove to Polk Springs	377	212	589
Polk Springs to 16-Mile Mark	597	567	1,164
16-Mile Mark to 10-Mile Mark	90	135	225
10-Mile Mark to 1-1/2-Mile Mark	50	95	145
Totals	1,545	1,159	2,704

Remarks: The estimated total spring-run of salmon into Deer Creek in 1941 was approximately 7,000 on the basis of 1 female and 1.65 males to each actual nest. This was the ratio in which the dead salmon were recovered during the spawning.

APPENDIX TABLE 13

MORTALITY OF SALMON TRANSFERRED FROM KESWICK DAM TO DEER CREEK, JUNE, 1943.

Date	Salmon transferred	Mortality in tanks	Mortality at weir	Mortality in stream	Total mortality
June 1	85				
2	187				
3	330	4	1		5
4	334	7	11		18
5	432	160	18		178
6	250	49	16		65
7	496	7	52		59
8	348	15	52		67
9	325	3	34	27	64
10	191	0	55	1	56
11	297	5	42	62	109
12	380	2	22		24
13	354	1	28		29
14	164	1	17		18
15	194	0	18	31	49
16	104	1	18	61	80
17	114	3	18		21
18	39	0	19	18	37
19	33	0	3	83	86
20	90	0	5	26	31
21	45	0	7	52	59
22	202	0	4	33	37
23	71	0	0	14	14
24	48	0	3	20	23
25	40	0	1		1
26	--	-	1		11
27	23	0	4		4
28	43	0	8		8
29	26	0	3	22	25
30	--	-	4	17	21
July 1	--	-	1	11	12
2	--	-	-	--	--
3	--	-	7	18	25
4	--	-	-	--	--
5	--	-	2	--	2
7	--	-	-	1	1
8	--	-	2	14	16
10	--	-	1		1
12	--	-	-	11	11
19	--	-	-	3	3
21	--	-	-	3	3
Totals	5,245	258	487	528	1,273

APPENDIX TABLE 14

Weekly seaward migrant catch record, Deer Creek 1942

Date[1]	Number of fry in fykes	Number of fry in traps	Total fry catch	Total hours fishing	Number of fry per 100 fishing hours
January					
21	16		16	136	11.7
28	6	2	8	94	8.5
February					
4	15		15	109	13.7
11	6		6	85	7.5
18	7		7	210	3.3
25	3	5	8	319	2.5
March					
4	4		4	233	1.7
11	25	5	30	256	11.7
18	69	32	101	297	34.0
25	23	5	28	347	8.1
April					
1	12		12	278	4.3
8	21	3	24	222	10.8
15	12		12	92	13.0
22	27		27	108	25.0
29	16		16	100	16.0
May					
6	6	1	7	151	4.6
13	12		12	104	11.5
20	8		8	108	7.4
27	4		4	105	3.8
June					
3	0		0	105	0.0
6	1		1	60	1.6
Totals	293	53	346	3,519	9.83

[1]First fry taken December 23, 1941, and included in week of January 14-21, 1942. No fishing between December 23, 1941, and January 14, 1942, because of flood waters. Other high water periods made fishing impossible on four days in late January, three days in February, and two days in April.

APPENDIX TABLE 15

Seaward migrant data for Deer Creek, 1943.

Date	Number of fry in fykes	Total hours of fishing	Number of fry per 100 fishing hours
February			
16	10	105	9.5
23	4	90	4.4
March			
2	13	55	23.6
9	10	45	22.2
16	8	105	7.6
23	6	105	5.7
30	7	105	6.6
April			
6	8	105	7.6
13	1	105	.9
20	7	106	6.7
27	4	109	3.7
May			
4	13	109	11.9
11	2	107	1.8
18	4	106	3.8
25	1	105	.9
June			
1	0	105	0.0
7	1	90	1.1
Totals	99	1,657	5.97

APPENDIX TABLE 16

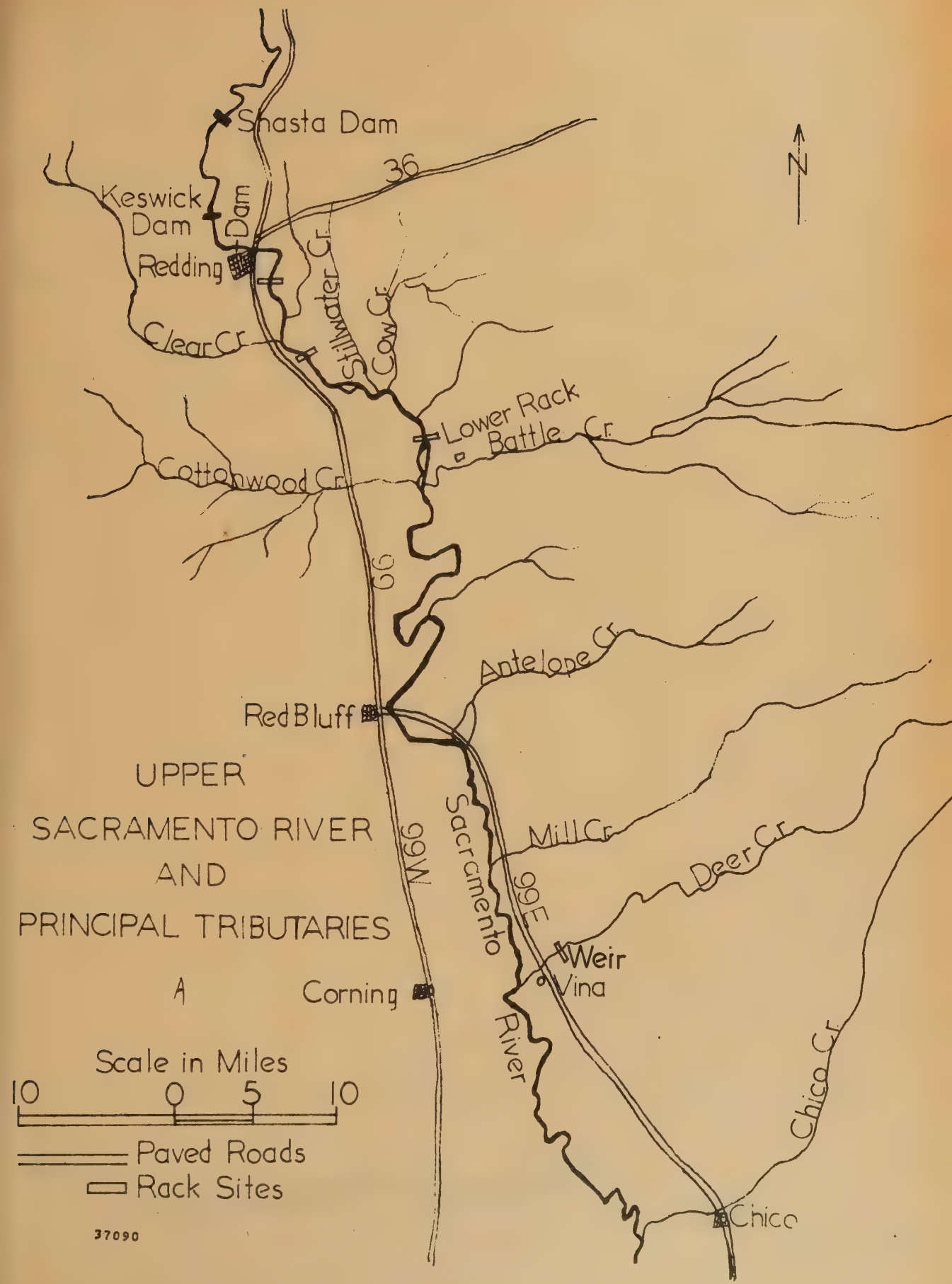
Daily water temperatures at the Deer Creek Weir
1941-1942

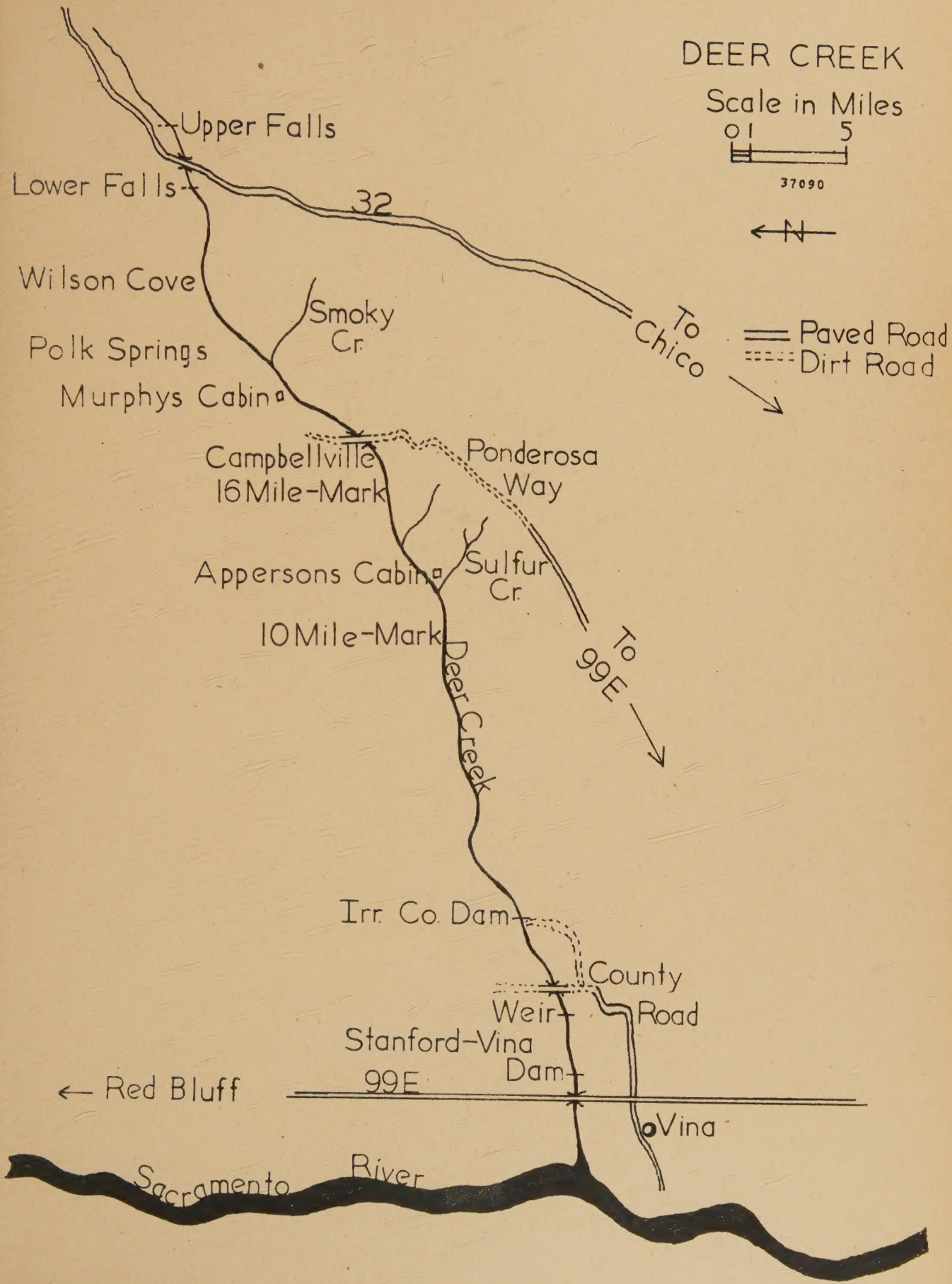
	1941			1942		
Day	May	June	July	May	June	July
1		63	80	55	65	82
2		64	78	56	64	82
3		64	79	60	66	83
4		67	80	58	67	
5		66	82	60	68	
6		66	82	63	67	
7		65	84	63	67	
8		67	82	63	67	
9		70	84	56	68	
10		74	84	55	68	
11		74		54	67	
12		77	82	53	69	
13		76	81	58	71	
14		72	79		72	
15		72	83	58	70	
16		68	79	60	71	
17		70		62	71	
18		72		62	70	
19		69	81	63	71	
20	66	72	83	67	71	
21	67	70		67	71	
22	70	64	86	65	73	
23	70	71	78	64	75	
24	68	67	80	63	75	
25	67	69	79	60	72	
26	62	70	75	57	71	
27	64	70	75	63	72	
28	60	73	79	58	76	
29	60	76	79	60	78	
30	61	79	80	61	79	
31	63		81	63		

APPENDIX TABLE 17

Maximum water temperatures at Balls Ferry bridge, Sacramento River, California, July 29, 1941-Oct. 25, 1941

Date	Temp. °F	Date	Temp. °F
July 29	73	Sept. 13	64
30	73	14	64
31	74	15	64
Aug. 1	72	16	64
2	73	17	64
3	72	18	60
4	72	19	60
5	73	20	59
6	72	21	59
7	72	22	59
8	72	23	60
9	72	24	60
10	71	25	61
11	71	26	62
12	69	27	62
13	72	28	62
14	72	29	62
15	74	30	61
16	73	Oct. 1	60
17	72	2	61
18	72	3	61
19	72	4	59
20	72	5	58
21	72	6	58
22	71	7	56
23	70	8	56
24	70	9	56
25	70	10	56
26	70	11	55
27	68	12	54
28	67	13	55
29	66	14	55
30	65	15	55
31	65	16	56
Sept. 1	64	17	57
2	65	18	56
3	66	19	55
4	67	20	56
5	No record	21	55
6	" "	22	54
7	" "	23	51
8	" "	24	50
9	" "	25	48
10	" "		
11	" "		
12	65		


Shasta Dam
Keswick Dam
Keswick Dam
Redding
36
N
Stillwater Cr.
Cow Cr.
Clear Cr.
Lower Rack
Battle Cr.
Cottonwood Cr.
99
Antelope Cr.
Red Bluff
UPPER
SACRAMENTO RIVER
AND
PRINCIPAL TRIBUTARIES
99W
Sacramento
River
Mill Cr.
99E
Deer Cr.
Weir
Vina
Corning
Chico Cr.
Chico
Scale in Miles
10 0 5 10
Paved Roads
Rack Sites
37090


DEER CREEK
Scale in Miles
0 1 5
37090
N
Upper Falls
Lower Falls
32
Wilson Cove
Smoky Cr.
Polk Springs
Murphys Cabin
To Chico
Paved Road
Dirt Road
Campbellville
16 Mile-Mark
Ponderosa Way
Appersons Cabin
Sulfur Cr.
10 Mile-Mark
Deer Creek
To 99E
Irr. Co. Dam
County Road
Weir
Stanford-Vina Dam
99E
Red Bluff
Vina
Sacramento River